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E-CIGARETTE MINIMUM LEGAL SALE AGE LAWS, TRADITIONAL CIGARETTE USE, AND BIRTH OUTCOMES AMONG RURAL, PREGNANT TEENAGERS

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E-Cigarette Minimum Legal Sale Age Laws, Traditional Cigarette Use, and Birth Outcomes among Rural, Pregnant Teenagers

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ABSTRACT

Restricting access to e-cigarettes for pregnant teenagers may decrease smoking cessation during pregnancy. We investigate the effect of e-cigarette minimum legal sale age laws on prenatal cigarette smoking and birth outcomes for underage teenagers using data on all births from 2010 to 2016 from 32 states. New panel data provides smoking information at four points in time for each teenager. We find that among rural underage teenagers, e-cigarette minimum legal sale age laws increased prenatal smoking by 0.6 percentage points (pp) overall and by 1.8 pp for those smoking in the 3 months prior to their pregnancy. These effects are especially large for black, rural teenagers who experience increases of 1.6 pp overall, and of 2.4 pp among smokers prior to pregnancy. Our results may indicate an unmet desire and need for assistance with smoking cessation.

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Introduction

Smoking is one of the leading causes of poor birth outcomes in the United States (U.S. Department of Health and Human Services, 2014). For this reason, women smokers may be especially motivated to quit smoking during pregnancy, with subsequent health benefits for both themselves and their offspring.

The relatively recent introduction of electronic nicotine delivery systems (ENDS) (which people *vape* rather than *smoke*) has provided pregnant women with a smoking cessation product option similar in some respects to FDA-approved nicotine replacement therapies (e.g. patch, gum) and smoking cessation medications (e.g. Chantix, Zyban). However, the safety of using ENDS for smoking cessation during pregnancy has received an inconclusive grade from the United States Preventive Services Task Force (Siu & Force, 2015). Vaping during pregnancy is risky primarily because nicotine, which is in most ENDS, is harmful to the developing fetus (Royal College of Physicians, 2016).

Minimum legal sale age (MLSA) laws have long been in place for traditional cigarettes. The passage of such laws for ENDS may reduce access to ENDS among pregnant underage teens. If teens lack access to other ways to reduce smoking during pregnancy, then this reduced access to ENDS could have the unintended consequence of reducing the extent to which the smoking of conventional cigarettes declines as pregnancy progresses. Thus, the extent to which pregnant women switch from cigarette smoking to ENDS, and the extent to which this switching is reduced by ENDS MLSAs, could indicate an unmet desire and need for smoking cessation assistance.

The objective of our paper is to evaluate the effect of ENDS MLSAs on the smoking of traditional cigarettes and on birth outcomes. Our paper is the first to explore the effect of ENDS MLSAs on pregnant teens' smoking. A previous study found that among adult pregnant women living in states that comprehensively banned indoor smoking of traditional cigarettes in public places, indoor vaping restrictions increased within-pregnancy smoking by 2.0 percentage points (pp), or 31% of the mean. However, these indoor vaping restrictions had no measurable impact on birth outcomes including low birth weight, premature birth, small-for-gestational age, and Apgar 5 score, perhaps because substituting one form of nicotine for another is not health improving for the developing fetus (Cooper & Pesko, 2017).

The current paper revisits the important question of the impact of ENDS regulations on prenatal smoking and birth outcomes using ENDS MLSAs as an alternative source of policy variation, and focusing on pregnant teens. In addition, we look carefully at which demographic groups are most affected, and find that the effects are concentrated on rural teens, and especially rural African-American teens.

Our focus on the effect of ENDS MLSAs in rural areas is important because rural areas account for a disproportionate share of teen pregnancies: 4.9% of rural 15 to 19 year old females give birth compared to 3.8% in urban areas and 2.4% in suburban areas. Additionally, since 2007, the rate of teen births is falling more slowly in rural counties than in urban and suburban counties, so the gap in teen birth rates between rural and urban areas is increasing (Hamilton, Rossen, & Branum, 2016). Prenatal smoking rates are also much higher among rural underage pregnant teens—in 2016 10.2% of rural underage pregnant teens smoked compared

to 5.8% in suburban areas and 2.4% in urban areas.[1] Therefore, our focus on rural areas captures a disproportionate share of teen prenatal smokers.

Similar to the paper evaluating the effects of ENDS indoor vaping restrictions on prenatal smoking (Cooper & Pesko, 2017), our study also makes a methodological contribution to studies of prenatal smoking in general by using recently revised birth records to exploit smoking information provided for the same individual pregnancy at four points in time. Analyzing this data using person fixed effects allows us to control for unobserved time-invariant individual-level heterogeneity.

A key assumption underlying our analysis is that in the absence of ENDS MLSA restrictions, smoking would have followed parallel trends in counties with and without such restrictions. We find that this parallel trends assumption is satisfied for rural areas, and that within these counties ENDS MLSAs increased smoking by 0.6 pp overall (4.5% of the mean) and by 1.6 pp for black teens (31.4% of the mean). These effects are concentrated among teens who smoked in the 3 months prior to their pregnancy. We find little evidence that ENDS MLSAs affected birth outcomes.

Background

Pregnant women have a high interest in quitting smoking: 55% of women smoking 3 months before their pregnancy are successfully able to quit smoking during their pregnancy (Centers for Disease Control and Prevention, 2015). Despite these high rates of successful quitting during pregnancy, the healthcare delivery system may not be assisting with smoking

[1] Based on author calculations using birth record data.

cessation during pregnancy as well as it could. According to data from four states in the 2009-2010 Pregnancy Risk Assessment Monitoring System, 75.4% of pregnant women receiving prenatal care and still smoking in the third trimester had been offered counseling, self-help materials, or referral to a state quitline, and 19.1% had been specifically advised to use nicotine replacement therapy (NRT) (Kapaya, Tong, & Ding, 2015).

Pharmacotherapy interventions for tobacco cessation for pregnant women continues to receive an incomplete grade from the United States Preventive Services Task Force due to uncertain evidence of the overall health benefits (U.S. Preventive Services Task Force, 2015); however, the Affordable Care Act now requires state Medicaid programs to cover pharmacotherapies for smoking cessation without cost sharing for pregnant women (Centers for Medicare & Medicaid Services, 2011).

The low rate of NRT prescribing for pregnant women may be because nicotine is a developmental toxicant that in itself could harm the fetus. However, potential harms to the fetus from NRT should be compared to potential benefits to the fetus from reduced prenatal smoking. A recent randomized controlled trial found some evidence ($p<0.10$) of reductions in prenatal smoking from nicotine patches, and no changes in birth outcomes (Coleman et al., 2012); however, the precision of the estimates was significantly limited by low sample sizes and low rates of compliance with the treatment regime. It is also possible that the use of NRT during pregnancy could reduce the infant's post-natal exposure to second hand smoke, but this hypothesis is untested.

If pregnant women are not satisfied with the services they are receiving for smoking cessation through prenatal care, or if these services are not available, they may look elsewhere

for help in quitting. Evidence from a systematic review of randomized controlled trials suggests that ENDS may be effective in eliminating and reducing cigarette consumption (Hartmann-Boyce et al., 2016). Given low utilization of nicotine replacement therapy among pregnant women, it is possible that pregnant women may disproportionately look to ENDS to reduce cigarette consumption.

Data on ENDS use among pregnant women is limited. The nationally-representative 2013-14 Population Assessment of Tobacco and Health interviewed 388 adult pregnant women, and of these 13.8% currently smoked, 4.9% currently vaped, and 28.5% of current smokers also vaped (Kurti et al., 2017). Among women of reproductive age in the same survey, 20.1% currently smoked, 5.9% currently vaped, and 22.5% of current smokers also vaped (Lopez et al., 2018). One small randomized controlled trial of pregnant women in Connecticut and Massachusetts who were unable to quit smoking on their own during pregnancy found that 14% vaped during pregnancy, usually in an effort to try to quit (Oncken et al., 2017).

Among teens generally, according to two national surveys, 2014 was the first year that more teens vaped ENDS over the past 30 days than smoked cigarettes (Arrazola et al., 2015; Miech, Johnston, O'Malley, Bachman, & Schulenberg, 2014). In response to rising ENDS use among youth, states have enacted ENDS MLSAs to reduce access to ENDS. MLSAs mimic laws that have long been in place in all states to reduce youth access to conventional tobacco products. ENDS MLSAs have been rolled out slowly over time. Five states had passed ENDS MLSAs by the end of 2010, 7 by the end of 2011, 12 by the end of 2012, 24 by the end of 2013, 39 by the end of 2014, and 47 by the end of 2015. By the end of 2016 all states had MLSAs in place because the Food and Drug Administration's Deeming Rule imposed an ENDS MLSA law of

18 nationally. At this point, only Pennsylvania had not yet passed a state law (Centers for Disease Control and Prevention, 2018).

Racial/ethnic groups in rural areas could respond differently to ENDS MLSAs given heterogeneity in both tobacco use rates and in prenatal care utilization. According to National Youth Tobacco Survey data from 2011-2015, the past 30-day vaping rates for rural female middle and high school students were 4.0% for white non-Hispanic teen females, 4.3% for black non-Hispanic teen females, and 3.6% for Hispanic teen females. The somewhat higher vaping rates among black non-Hispanics teens suggests they could be disproportionately affected by ENDS MLSAs. Black and Hispanic underage pregnant teens also receive fewer prenatal care visits and less timely prenatal care,[2] which could suggest greater unmet need for prenatal smoking cessation services and hence greater incentive to use ENDS.

ENDS MLSAs may inadvertently increase smoking among some pregnant teens by removing access to a smoking cessation device from a group of highly-motivated quitters. These higher rates of smoking could in turn worsen birth outcomes. At the same time, ENDS MLSAs may reduce vaping and associated exposure to nicotine and other substances that could be present in vaping products, which could improve birth outcomes. Or a switch from cigarette smoking to vaping might have little effect on fetal health since both involve exposure to nicotine. Hence, the net effect of ENDS MLSAs on birth outcomes is ambiguous and requires empirical investigation.

[2] According to birth records, in 2016, white pregnant teens ≤17 years of age received 11.1 prenatal care visits compared to 9.9 for black teens and 9.5 for Hispanic teens. Prenatal care started 2 weeks later for rural black and Hispanic teens than for rural white teens.

Data

We use administrative birth records with geocoded information provided by the National Center for Health Statistics. The Standard Certificate of Live Birth was revised in 2003 and the revised form was slowly rolled out in different states over time.[3] The old form asked only about smoking at any time during pregnancy. The revised form asks about smoking prior to pregnancy and in each trimester. The accuracy of cigarette use during pregnancy is significantly improved in the revised form relative to the old form. For example, Howland et al. (2015) find that with the old form, maternal smoking agreed with hospital records 84% of the time, but this agreement improved to 94% with the revised form.

The introduction of the revised birth record form resulted in statistically significant increases in reported prenatal smoking in 21 out of 31 states, suggesting that the old form underreported smoking compared to the revised (Curtin & Mathews, 2016). In addition to the improved accuracy of the revised form, the collection of trimester-specific smoking information permits us to exploit within-individual variation in cigarette use in response to ENDS MLSAs in a panel data analysis. Figure 1 shows the question capturing cigarette use information as it appears on the revised birth record form. Unfortunately, no information about vaping is currently collected for birth records.

To capture infant mortality, we also use period-linked infant death data. These data show whether the infant died in the same calendar year in which they were born. These data capture approximately 86% of infant mortality, only missing mortality for infants who were born in one calendar year and died in the next calendar year. As of the writing of this paper,

[3] All states were using the revised birth records in 2015 (Centers for Disease Control and Prevention, 2014).

period-linked infant death was only available through the end of 2015 compared to birth certificates which are available through the end of 2016.

We use revised birth records data from 32 states (including D.C.) from 2010 to 2016.[4] We exclude 16 states that had not adopted revised birth records by 2010.[5] Further, we exclude Georgia and Michigan because information about cigarette use was missing for multiple years. Finally, we exclude Massachusetts because an unusually large number of ENDS laws were enacted at the city/town levels (New Jersey Global Advisors Smokefree Policy, 2015) and geocoded information in the birth records is only available for the county.

We perform our analysis using teens giving birth before their 18th birthday, so that they were younger than the ENDS MLSA throughout the full length of their pregnancy. We further restrict our sample to those teens whose estimated conception date (16 days after pregnancy week 0 or last menstrual period) was between 1/1/2010 and 1/1/2016.[6] We exclude non-singleton births and a small number of birth certificates with unknown gestational length.

We match ENDS MLSAs to the point of conception for our cross-sectional analysis, or to the start of each trimester for our panel data analysis.[7] We obtain implementation dates of ENDS MLSAs at the state-level from the CDC State System (Centers for Disease Control and Prevention, 2018) and from the National Conference of State Legislatures (National Conference

[4] Six of these 32 states were still using unrevised birth records in 2009, and so starting our analysis earlier would significantly reduce our sample. Further, the time period 2010-2016 nicely encompasses almost all of the variation in ENDS MLSAs. The first state (New Hampshire) in our study enacted an ENDS MLSA law in July, 2010.
[5] These states are AK, AL, AR, AZ, CT, HI, LA, ME, MN, MS, NC, NJ, RI, VA, WI, and WV.
[6] This strategy avoids bias arising from our sample being more likely to contain premature births at the end of our data, since only at the point of birth is a birth certificate generated.
[7] Using the month of birth information (provided in the birth records), we assume that the infant was born at the mid-point of the month recorded in the birth record. We then use gestational length in weeks (also provided in the birth records), to identify the estimated point of conception and the start of the three trimesters. The first trimester is defined as the point of ovulation that led to pregnancy. The second trimester is defined as week 14 of pregnancy (14 weeks after last menstrual period). And the third trimester is defined as week 28 of pregnancy.

of State Legislatures, 2016). We obtained county-level MLSAs from a white paper (New Jersey Global Advisors Smokefree Policy, 2015). Appendix Table 1 shows the states in our sample and the dates of their respective ENDS MLSAs. It also shows all county-level ENDS MLSAs that we used in our analysis. Appendix Figure 1 shows maps of the states and counties adopting the ENDS MLSAs at different points in time.[8]

Counties where the birth occurred are identified as urban/suburban or rural using the 2013 Urban-Rural Classification Scheme for Counties (Centers for Disease Control and Prevention, 2013). This ordinal, six-level scheme codes counties as (1) large central metro, (2) large fringe metro, (3) medium metro, (4) small metro, (5) micropolitan, and (6) noncore. Counties coded level 1-4 were classified as urban/suburban and counties coded levels 5 and 6 were classified as rural.

We control for other tobacco control policies including cigarette tax rates and indoor smoking and vaping restrictions in private workplace, bars, and restaurants. We match these controls to the point of conception for our cross-sectional analysis, or to the start of the trimester for our panel data analysis. We obtained these data from the CDC State System (Centers for Disease Control and Prevention, 2018).[9]

Descriptive statistics are reported in Table 1 for all underage pregnant teens and in Appendix Table 2 for only rural underage pregnant teens. The first columns show descriptive statistics for pregnant teens for whom an ENDS MLSA was not in place at any point during the

[8] Two states (MT and OR) passed ENDS MLSA's on 1/1/2016. This policy variation is used in panel models, affecting 2nd and 3rd trimester smoking for women conceiving in late 2015.

[9] We do not control for ENDS taxes because DC was the only state out of our 32 state sample that adopted an ENDS tax by the trimester start date for women conceiving on or before January 1, 2016, and we do not use DC in our preferred sample of rural counties.

pregnancy, the second columns show descriptive statistics for pregnant teens for whom an ENDS MLSA came into place between 3 months prior to conception and birth, and the third columns show descriptive statistics for pregnant teens from whom an ENDS MLSA was in place before 3 months prior to conception. Smoking rates were lowest in each trimester of pregnancy for mothers who were fully treated by ENDS MLSA laws, but since these records are more recent on average, this decline could be due to general declines in prenatal smoking rates over time. Third trimester smoking as a percent of smoking in the 3 months prior to pregnancy was 55.7% for non-treated teens, 54.5% for partially treated teens, and 52.2% for fully treated teens, suggesting that ENDS MLSAs decreased prenatal smoking cessation. Appendix Table 2 shows that in rural areas, smoking rates were lower for partially treated and fully treated teens than for non-treated teens.

We also provide descriptive statistics for outcomes (birth weight, low birth weight, very low birthweight, prematurity, APGAR scores), demographic variables (race/ethnicity, age, health insurance, and order of birth) and tobacco control policies (cigarette taxes and indoor air laws), all of which could be correlated with both adoption of ENDS MLSA laws and with prenatal smoking. Table 1 and Appendix Table 2 show that women who were partially or fully treated were more likely to be on Medicaid, less likely to be black, and less likely to have low birth weight babies than mothers who were untreated. Since characteristics differ between these three groups, it is important to control adequately for maternal characteristics when trying to assess the effects of MLSAs on outcomes.

Methods

In our primary analysis, we exploit the impact of ENDS MLSAs on within-pregnancy changes in smoking using a panel data analysis. The panel data regressions have the following specification:

(1) $$smoking_{icspt} = a + \beta_1 ENDS\ MLSA_{cst} + \beta_2 cig\ tax_{st} + \beta_3 indoor\ use_{st} + \gamma_i + \gamma_{pt} + e_{icspt},$$

where $smoking_{icspt}$ denotes any cigarette use at period *p* (either the three months prior to pregnancy or in each trimester), for pregnant teen *i* living in county *c* of state *s* of year-month *t* in which the trimester began. We control for pregnancy fixed effects in order to remove individual-level heterogeneity and we control for trimester-year-month fixed effects in order to remove heterogeneity unique to trimesters starting at different points in time. We also control for time-varying tobacco control policies including cigarette taxes and indoor use laws for cigarettes, and for laws restricting ENDS in private workplaces, restaurants, and bars from the start of the period *p*.[10] Our coefficient of primary interest is β_1 which shows how ENDS MLSAs that were enacted during a given pregnancy caused changes in cigarette use beyond the normal declines expected as pregnancy progresses. We expect this relationship to be positive if ENDS are substitutes for traditional cigarette use, and negative if they are complements. We do not control for county fixed effects because we only observe one location per pregnancy; therefore, pregnancy fixed effects control for location.

[10] We control for each tobacco type/venue separately using indicators for no restrictions, partial restrictions, or full restrictions.

We also modify equation (1) to perform an event study (Autor, 2003) to ask whether our results are impacted by time varying omitted variables bias. We replace the previous ENDS MLSA indicator variable with a set of mutually exclusive policy leads and lags that divide the time period into these categories: trimester started >30 months before the MLSA was passed, 21-30 months before, 12-21 months before, 3-12 months before (reference), 0-3 months before (e.g. law was passed within this trimester), 0-9 months after, and >9 months after. Outside of including these mutually exclusive policy leads and lags instead of the standard DD variable, the resulting equation is identical to (1). In this event study specification, the policy "leads" provide evidence about whether within-pregnancy smoking rates were changing among pregnant teens prior to passage of ENDS MLSAs, which would suggest time-varying omitted variables bias or anticipatory behaviors.

We estimate separate models for groups defined by demographic characteristics and urban/rural location, since these groups may be expected to have different access to prenatal care and smoking cessation services. First, we estimate stratified models by urban/suburban and then rural counties to investigate the crucial identifying assumption of parallel trends in smoking for the treatment and control groups prior to the passage of ENDS MLSAs. We find evidence of parallel pre-trends only for rural counties, suggesting that there were unobserved factors affecting teens differentially in urban/suburban areas adopting ENDS MLSAs.

We therefore focus on rural counties for the remaining analyses. In the sample of rural counties, we estimate models stratified by white non-Hispanic, black non-Hispanic, and

Hispanic given previously discussed differences in smoking/vaping and prenatal care among these populations.[11]

Finally, we also estimate the effects of ENDS MLSAs on birth outcomes in a cross-sectional DD specification. We cannot use a panel data analysis for birth outcomes since we have just one birth outcome per pregnancy (compared to four smoking observations per pregnancy). For this analysis, we estimate the following equation:

(2) $birth\ outcome_{icst} = a + \beta_1 ENDS\ MLSA_{cst} + \beta_2 cig\ tax_{st} + \beta_3 indoor\ use_{st} + X_i + \gamma_{cs} + \gamma_t + e_{icst}$,

In equation (2) individual fixed effects are replaced with a vector of individual characteristics including: mother's race, age dummies (≤14, 15, 16, 17), payment source (e.g. Medicaid, private insurance, self pay)[12], and the birth order of her current birth (1, 2, […] 7, ≥8). We continue to control for cigarette taxes as well as indoor air laws affecting cigarettes and ENDS use in restaurants, bars, and private workplaces (from point of gestation). We also control for month-year of gestation and county fixed effects. The birth outcomes that we model are mortality in the year of birth, continuous birthweight, low birthweight (<2,500 grams), very low birth weight (<1,500 grams), weeks of gestation, premature birth (<37 weeks), very premature birth (<32 weeks), and Apgar 5 score.

[11] A synthetic control group model could in theory also be used to establish parallel trends, but these models require significant pre-adoption data. Using data from before 2010 would cause us to lose a considerable number of states that were not using revised birth records before then. Therefore, we believe our approach of selecting a group of counties that does exhibit parallel trends is the strongest feasible methodology.

[12] Payment method also helps control for the mother's economic condition. Besides payment source, birth records do not provide any direct information on the teenager's employment status or economic support.

The coefficient of primary interest β_1 from equation (2) represents an average of two competing effects. β_1 could suggest worse birth outcomes if ENDS MLSAs cause more pregnant teens to smoke and if smoking is more dangerous than vaping to the developing fetus. Alternatively, β_1 could suggest better birth outcomes if ENDS MLSAs increase complete abstinence from nicotine by reducing stand-alone vaping. ENDS indoor vaping restrictions were found to have no effect on birth outcomes for adult pregnant women, potentially because these effects cancelled each other out (Cooper & Pesko, 2017). The current paper provides a opportunity to explore the effect of different types of regulations of ENDS on birth outcomes, and extends the literature by looking at the effects on rural teens, a group who are often neglected.

All regressions are estimated using linear models. Standard errors are clustered at the level of the county given that this is the lowest geographical level at which ENDS MLSAs were adopted.

Results

Table 2 shows results from equation (1) using smoking participation within a given time period as our outcome. Overall, Table 2 shows that the passage of ENDS MLSAs is associated with increases in within-pregnancy smoking participation by a modest 0.2 pp for all pregnant teens ($p<0.05$, 3.2% of the mean). This significant effect is driven by a 0.6 pp increase in smoking for rural pregnant teens ($p<0.05$, 4.5% of the mean), and by 1.6 pp for rural black pregnant teens ($p<0.10$, 31.4% of the mean).

Table 3 shows estimates of the event study version of our Table 2 results. These estimates ask whether within-pregnancy smoking patterns were changing in the time period leading up to or after ENDS MLSA adoption. We also show the same event study coefficients graphically in Figure 2. This specification shows evidence of non-parallel trends for all teens and for urban/suburban pregnant teens, since the coefficients on the three policy leads are jointly statistically significant for all pregnant teens (p=0.024) and for urban/ suburban pregnant teens (p=0.020). The direction of the coefficients suggests that traditional cigarette use was *higher* in the pre-adoption period for the treatment group than the control group, suggesting that the positive but small DD coefficients we observe in Table 2 are actually underestimated.

For rural pregnant teens, coefficients in the pre-adoption period are all individually and jointly statistically insignificant. The coefficients are estimated to be zero in the two periods of time leading up to ENDS MLSA adoption. This result provides evidence that the parallel trends assumption is satisfied for rural pregnant teens, giving us confidence that the 0.6 pp increase in within-pregnancy smoking we observed for rural pregnant teens in Table 2 is not biased by uncontrolled time-varying heterogeneity.

The coefficients in the post period suggest a persistent and increasing effect for rural black teens, with smoking participation increasing by 2.5 pp (p<0.05) in trimesters starting 0-9 months after the ENDS MLSA came into effect (compared to 3-12 months before) and by 3.9 pp (p<0.05) in trimesters >9 months after the ENDS MLSA came into effect. However, the period of time >9 months after MLSA should be interpreted cautiously because late adopting counties do not contribute variation to this coefficient. The passage of ENDS MLSAs does not appear to affect all rural pregnant teens >9 months after adoption, either because ENDS MLSAs only

reduces teen prenatal smoking temporarily or because the effects in early-adopting ENDS MLSA counties are different than in late-adopting counties.

Tables 4 and 5 stratify the results by pregnant teens who smoked in the 3 months prior to their pregnancy and those who did not. If ENDS MLSAs affect prenatal smoking primarily by impacting smoking cessation rather than by affecting initiation of smoking, then ENDS MLSAs will have no effect on traditional cigarette use among teens who were not already smoking prior to their pregnancies, but ENDS MLSAs could have large impacts on teens who were smoking prior to their pregnancies since these teens may attempt to quit smoking with ENDS.

The estimates support this hypothesis. ENDS MLSAs had virtually no effect on teens who were non-smokers prior to pregnancy and had sizable effects (although sometimes imprecisely estimated) on smokers prior to pregnancy. For example, ENDS MLSAs increased within-pregnancy smoking by 1.8 pp (p>0.10, 2.5% of the mean) among rural pregnant teens who smoked in the three months prior to their pregnancy. For rural black teens who smoked prior to their pregnancies, within-pregnancy smoking increased by 24.2 pp (p<0.05, 35.7% of the mean).

Table 6 shows estimates of the effects of ENDS MLSAs on birth outcomes for all rural teens. These estimates are from equation (2). ENDS MLSAs may improve birth outcomes by reducing overall nicotine exposure from traditional cigarettes and ENDS combined, but they could also harm birth outcomes since ENDS MLSAs reduce smoking cessation among pregnant teens. There is inconsistent evidence of effects on birth outcomes among all rural teens. While very premature birth declined by 0.5 pp (p<0.05), the coefficient on gestational length is positive, so there is no consistent evidence that ENDS MLSAs affected gestation outcomes.

The corresponding event study for the birth outcomes, using one year intervals of time, is provided in Table 7 and Figure 3. These results provide evidence that the parallel trends assumption is satisfied in this sample of rural births. There is some evidence that birth outcomes improved for women conceiving 0-1 years after ENDS MLSA laws came into place--infant mortality fell by 0.5 pp (p<0.05) relative to infants conceived 1-2 years before the ENDS MLSA came into place, birth weight increased by 23.4 grams (p<0.10), and very premature birth declined by 0.7 pp (p<0.10). However, except for very premature birth, these effects were not observed in the standard difference-in-differences coefficients in Table 6. Our overall findings of little if any effect of ENDS MLSAs on birth outcomes closely matches the findings of the effects of indoor vaping restrictions on birth outcomes for adult pregnant women (Cooper & Pesko, 2017) and may suggest that substituting one source of nicotine (cigarettes) for another (ENDS) during pregnancy is not health improving for the infant.

Discussion

This paper suggests that increases in teen prenatal cigarette smoking may be an unintended consequence of ENDS MLSAs among rural teens. Our best estimate of a 0.6 pp increase in within-pregnancy smoking among rural teens, derived using a model with person-specific fixed effects that exploits variation in smoking over pregnancy, is slightly smaller than previous estimates for teens generally (not specifically rural, nor pregnant) from cross-sectional difference-in-differences models. Three other studies found that ENDS MLSAs increased teen smoking by approximately 0.8 to 1.0 pp (Dave, Feng, & Pesko, 2017; Friedman, 2015; Pesko,

Hughes, & Faisal, 2016).[13] Our estimate may be somewhat attenuated from the first three estimates because our results are for a subset of women rather than both men and women, and women generally have lower tobacco use rates than men.

We find especially large effects of ENDS MLSAs on rural black teens, who experience a 1.6 pp increase in within-pregnancy smoking. According to National Youth Tobacco Survey data, rural black female students use ENDS at a higher rate than white and Hispanic female students, so this population may be particularly affected by ENDS MLSAs. Rural black pregnant teens also receive less prenatal care than rural white pregnant teens, which may mean that they have less access to smoking cessation treatments while pregnant. The additional prenatal care received by white rural teens could in turn account for why we see no effects of ENDS MLSAs on this group.[14]

Finally, it's possible that rural black pregnant teens may be more motivated to try to quit smoking during pregnancy than rural white pregnant teens and so they might be more impacted by the loss of access to ENDS. In our data, among white and black rural teens smoking prior to pregnancy, 43% of rural black teens quit smoking within a given trimester compared to only 33% of rural white teens, suggesting that rural, black, pregnant teens may be potentially more eager to use ENDS to quit (if they can buy them legally).

13 A fourth study used Monitoring the Future data to find that ENDS MLSAs decreased high school senior smoking participation by 2.0 pp (Abouk & Adams, 2017), but another study has since challenged the generalizability of using this population to evaluate the effect of tobacco retail compliance inspections, and by extension other tobacco control policies (Feng & Pesko, Forthcoming).

[14] Our results could also be driven by discrimination—perhaps stores are more likely to illegally sell ENDS to rural white teenagers than to rural black teenagers, which would cause larger effects on smoking for black teenagers, but we can only speculate about this.

One limitation of our study is that we are unable to look at the future health of the mother and their infants. Teens who miss an opportunity to quit smoking during pregnancy may be less likely to quit smoking later in life leading to greater health risks to both themselves and to their infants. While 55% of women quit smoking during pregnancy, 40% of these mothers have historically relapsed within 6 months of giving birth (Centers for Disease Control and Prevention, 2015). If ENDS could help reduce both prenatal smoking and postnatal smoking (by preventing relapse), then this could be a significant mechanism through which ENDS MLSAs could improve population health. However, this is a hypothesis that we are unable to explore using birth certificate data.

We are also unable to look at future health of the infant outside of first-year mortality. Higher postnatal smoking rates could adversely impact infant health through higher secondhand smoke exposure. The Surgeon General concluded that while ENDS aerosol is not harmless, it generally contains fewer toxicants than combustible tobacco products (U.S. Department of Health and Human Services, 2016).

A strength of our study is that we exploit the trimester-specific smoking information provided in revised birth records to examine the within-pregnancy effects of ENDS MLSAs. However, a second limitation of our study is that birth records have no information about vaping, so we are unable to examine this behavior directly. With the increasing use of ENDS, states should consider adding ENDS use information to the birth records. Additionally, states may wish to consider adding questions on smoking cessation behavior, such as through use of nicotine replacement therapy.

Our study suggests that there may be a high unmet demand among pregnant rural teenage women for smoking cessation products, which is why we believe that some turn to vaping. Pregnancy may provide a unique window when women are open to guidance about resources and products available to help them to quit smoking. In the absence of such guidance, pregnant women may be more likely to use ENDS. Tobacco cessation pharmacotherapy interventions for pregnant women have received an “incomplete” grade from the United States Preventive Services Task Force due to uncertain evidence about their overall health benefits (U.S. Preventive Services Task Force, 2015). There may be substantial value in encouraging pregnant women's use of tobacco cessation interventions to reduce prenatal smoking, and in physicians providing counselling and assistance to pregnant women who are trying to quit smoking.

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Table 1: Descriptive Statistics from Birth Records, 2010-2016

	No Treatment		Partial Treatment		Full Treatment	
	mean	sd	mean	Sd	mean	sd
Smoking Participation Before Pregnancy	0.097	0.297	0.077	0.267	0.067	0.249
Smoking Participation in First Trimester	0.072	0.259	0.057	0.231	0.049	0.216
Smoking Participation in Second Trimester	0.058	0.234	0.045	0.207	0.038	0.190
Smoking Participation in Third Trimester	0.054	0.227	0.042	0.201	0.035	0.183
White non-Hispanic	0.330	0.470	0.290	0.454	0.272	0.445
Black non-Hispanic	0.211	0.408	0.182	0.386	0.157	0.363
Hispanic	0.425	0.494	0.479	0.500	0.515	0.500
Other non-Hispanic or Missing	0.034	0.181	0.049	0.216	0.056	0.231
14 or younger	0.041	0.197	0.038	0.191	0.036	0.186
15	0.122	0.327	0.116	0.320	0.116	0.320
16	0.292	0.455	0.295	0.456	0.291	0.454
17	0.546	0.498	0.552	0.497	0.557	0.497
Medicaid	0.742	0.438	0.766	0.423	0.775	0.418
Private Insurance	0.142	0.349	0.146	0.353	0.157	0.364
Self-pay	0.051	0.220	0.038	0.192	0.026	0.160
Indian Health Service	0.002	0.041	0.001	0.031	0.000	0.022
CHAMPUS/TRICARE	0.002	0.049	0.003	0.054	0.003	0.057
Other government insurance	0.008	0.089	0.016	0.125	0.018	0.133
Other	0.041	0.198	0.023	0.149	0.009	0.096
Unknown	0.012	0.110	0.007	0.081	0.011	0.103
Mother's birth count (living and dead)	1.141	0.408	1.130	0.392	1.123	0.384
Urban	0.361	0.480	0.407	0.491	0.420	0.494
Suburban	0.492	0.500	0.475	0.499	0.488	0.500
Rural	0.147	0.354	0.119	0.323	0.092	0.289
Birth weight (in grams)	3153.596	549.071	3165.781	547.579	3175.313	547.686
Low Birth Weight (<2500 grams)	0.089	0.285	0.085	0.278	0.082	0.275
Very Low Birth Weight (<1500 grams)	0.015	0.123	0.015	0.121	0.015	0.120
Gestation Length (in weeks)	38.511	2.824	38.549	2.757	38.617	2.658
Premature Birth (<37 weeks)	0.145	0.352	0.137	0.344	0.126	0.332
Very Premature Birth (<32 weeks)	0.028	0.164	0.026	0.159	0.024	0.153
Apgar 5 Score	8.723	0.946	8.760	0.890	8.783	0.843
ENDS MLSA	0.000	0.000	0.328	0.469	1.000	0.000
Cigarette taxes ($)	1.388	0.735	1.353	0.894	1.325	1.015
Cigarette private workplace indoor use law: None	0.422	0.494	0.239	0.427	0.045	0.208
Cigarette private workplace indoor use law: Partial	0.091	0.288	0.292	0.455	0.464	0.499
Cigarette private workplace indoor use law: Full	0.487	0.500	0.468	0.499	0.491	0.500
ENDS private workplace indoor use law: None	0.998	0.041	0.998	0.050	0.978	0.146

ENDS private workplace indoor use law: Full	0.002	0.041	0.002	0.050	0.022	0.146
Cigarette restaurant indoor use law: None	0.420	0.494	0.239	0.427	0.045	0.208
Cigarette restaurant indoor use law: Partial	0.173	0.378	0.338	0.473	0.535	0.499
Cigarette restaurant indoor use law: Full	0.407	0.491	0.423	0.494	0.420	0.493
ENDS restaurant indoor use law: None	0.998	0.041	0.998	0.050	0.978	0.146
ENDS restaurant indoor use law: Full	0.002	0.041	0.002	0.050	0.022	0.146
Cigarette bar indoor use law: None	0.649	0.477	0.435	0.496	0.235	0.424
Cigarette bar indoor use law: Partial	0.053	0.223	0.258	0.437	0.437	0.496
Cigarette bar indoor use law: Full	0.299	0.458	0.307	0.461	0.328	0.469
ENDS bar indoor use law: None	0.998	0.041	0.998	0.050	0.978	0.146
ENDS bar indoor use law: Full	0.002	0.041	0.002	0.050	0.022	0.146
Observations	196332		37600		95452	

Population of women giving birth <18 years of age from 32 states meeting inclusion criteria. Policy variables are as of the start of the first trimester.

Table 2: Smoking Participation, Longitudinal, DD

	(1) All	(2) Urban/Suburban	(3) Rural	(4) Rural, White NH	(5) Rural, Black NH	(6) Rural, Hispanic
MLSA Law=1	0.002*	0.001	0.006*	0.004	0.016+	0.002
	(0.001)	(0.001)	(0.003)	(0.005)	(0.008)	(0.004)
Obs	1,323,244	1,154,488	168,756	100,300	11,068	44,780
MLSA Law Mean	0.345	0.358	0.259	0.281	0.219	0.213
Dep. Var. Mean	0.062	0.052	0.132	0.190	0.051	0.028
Adjusted R^2	0.027	0.023	0.051	0.067	0.032	0.020
# Clusters	1215	515	700	662	328	556

Standard errors in parentheses
Population of women giving birth <18 years of age that were conceived between 1/1/2010 and 1/1/2016. We control for pregnancy fixed effects, trimester-year-month fixed effects, cigarette taxes, and cigarette and ENDS indoor air laws in bars, private workplaces, and restaurants. Standard errors are clustered at the level of county.
$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Smoking Participation, Longitudinal, Event Study

	(1) All	(2) Urban/Suburban	(3) Rural	(4) Rural, White NH	(5) Rural, Black NH	(6) Rural, Hispanic
Trim. Started >30 Months Before MLSA=1	0.013**	0.011*	0.006	-0.007	-0.006	0.009
	(0.005)	(0.005)	(0.006)	(0.008)	(0.014)	(0.008)
Trim. Started 21-30 Months Before MLSA=1	0.009**	0.008**	-0.000	-0.008	-0.011	0.006
	(0.003)	(0.003)	(0.005)	(0.007)	(0.011)	(0.006)
Trim. Started 12-21 Months Before MLSA=1	0.005**	0.005**	-0.000	-0.002	-0.003	0.000
	(0.002)	(0.002)	(0.003)	(0.005)	(0.008)	(0.004)
Trim. Started 0-3 Months Before MLSA=1	0.001	0.001	0.003	0.005	0.012	0.004
	(0.001)	(0.001)	(0.003)	(0.004)	(0.009)	(0.004)
Trim. Started 0-9 Months After MLSA=1	0.002	0.001	0.007+	0.007	0.025*	0.004
	(0.001)	(0.002)	(0.004)	(0.006)	(0.012)	(0.005)
Trim. Started >9 Months After MLSA=1	-0.001	-0.001	-0.001	0.005	0.039*	-0.004
	(0.003)	(0.003)	(0.006)	(0.009)	(0.019)	(0.008)
Obs	1,323,244	1,154,488	168,756	100,300	11,068	44,780
MLSA Law Mean	0.345	0.358	0.259	0.281	0.219	0.213
Dep. Var. Mean	0.062	0.052	0.132	0.190	0.051	0.028
Adjusted R^2	0.027	0.023	0.051	0.067	0.032	0.020
# Clusters	1215	515	700	662	328	556
Policy Lead Joint p-Val	0.024	0.020	0.265	0.517	0.727	0.508

Standard errors in parentheses
Population of women giving birth <18 years of age that were conceived between 1/1/2010 and 1/1/2016. Reference group is trimester started 3-12 months before MLSA. We control for pregnancy fixed effects, trimester-year-month fixed effects, cigarette taxes, and cigarette and ENDS indoor air laws in bars, private workplaces, and restaurants. Standard errors are clustered at the level of county.
$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Smoking Participation Among Smokers Prior to Pregnancy, Longitudinal, DD

	(1)	(2)	(3)	(4)	(5)	(6)
	All	Urban/Suburban	Rural	Rural, White NH	Rural, Black NH	Rural, Hispanic
MLSA Law=1	-0.001	-0.006	0.018	0.000	0.242*	0.050
	(0.008)	(0.010)	(0.015)	(0.016)	(0.118)	(0.060)
Obs	114,000	83,796	30,204	25,212	820	2,040
MLSA Law Mean	0.273	0.283	0.247	0.252	0.195	0.225
Dep. Var. Mean	0.713	0.706	0.733	0.752	0.677	0.599
Adjusted R^2	0.324	0.333	0.302	0.281	0.465	0.482
# Clusters	1087	492	595	568	121	233

Standard errors in parentheses
Population of women giving birth <18 years of age that were conceived between 1/1/2010 and 1/1/2016. We control for pregnancy fixed effects, trimester-year-month fixed effects, cigarette taxes, and cigarette and ENDS indoor air laws in bars, private workplaces, and restaurants. Standard errors are clustered at the level of county.
$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Smoking Participation Among Non-Smokers Prior to Pregnancy, Longitudinal, DD

	(1)	(2)	(3)	(4)	(5)	(6)
	All	Urban/Suburban	Rural	Rural, White NH	Rural, Black NH	Rural, Hispanic
MLSA Law=1	0.000	-0.000	0.001	0.001	0.003	-0.001
	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)	(0.001)
Obs	1,209,244	1,070,692	138,552	75,088	10,248	42,740
MLSA Law Mean	0.352	0.363	0.261	0.291	0.221	0.213
Dep. Var. Mean	0.001	0.000	0.001	0.002	0.000	0.000
Adjusted R^2	0.000	0.000	0.001	0.001	0.012	0.002
# Clusters	1207	510	697	654	310	542

Standard errors in parentheses
Population of women giving birth <18 years of age that were conceived between 1/1/2010 and 1/1/2016. We control for pregnancy fixed effects, trimester-year-month fixed effects, cigarette taxes, and cigarette and ENDS indoor air laws in bars, private workplaces, and restaurants. Standard errors are clustered at the level of county.
$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Smoking and Birth Outcomes, Cross Sectional, Rural Underage Pregnant Women, DD

	(1) Mortality in Year of Birth	(2) Continuous Birthweight	(3) Low Birthweight	(4) Very Low Birthweight	(5) Weeks of Gestation	(6) Premature	(7) Very Premature	(8) Apgar 5
ENDS MLSA	-0.0006	6.4128	0.0000	0.0003	0.0317	-0.0031	-0.0053*	-0.0158
	(0.0012)	(9.2826)	(0.0045)	(0.0015)	(0.0515)	(0.0069)	(0.0026)	(0.0239)
Obs	38,659	42,388	42,388	42,388	42,403	42,403	42,403	42,283
MLSA Law Mean	0.187	0.241	0.241	0.241	0.241	0.241	0.241	0.241
Dep. Var. Mean	0.005	3228.435	0.060	0.008	38.776	0.121	0.020	8.728
Adjusted R^2	0.028	0.036	0.009	0.023	0.026	0.011	0.016	0.082
# Clusters	701	702	702	702	704	704	704	692

Standard errors in parentheses
Population of women giving birth <18 years of age that were conceived between 1/1/2010 and 1/1/2016 (only through 1/1/2015 for mortality). Controlling for mother's race, age, payment source, order of birth, cigarette taxes at point of gestation, cigarette and ENDS indoor air laws in bars, private workplaces, and restaurants, month-year of gestation, and county. Standard errors are clustered at the level of county.
+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: Smoking and Birth Outcomes, Cross Sectional, Rural Underage Pregnant Women, Event Study

	(1) Mortality in Year of Birth	(2) Continuous Birthweight	(3) Low Birthweight	(4) Very Low Birthweight	(5) Weeks of Gestation	(6) Premature	(7) Very Premature	(8) Apgar 5
Conception Started >3 Years Before MLSA	0.0036	5.4705	-0.0051	-0.0019	-0.0286	0.0029	0.0015	0.0058
	(0.0024)	(13.5836)	(0.0069)	(0.0025)	(0.0748)	(0.0094)	(0.0041)	(0.0341)
Conception Started 2-3 Years Before MLSA	-0.0003	0.0098	-0.0010	-0.0027	0.0428	-0.0008	-0.0006	0.0148
	(0.0015)	(10.2383)	(0.0048)	(0.0019)	(0.0548)	(0.0064)	(0.0031)	(0.0197)
Conception Started 0-1 Years Before MLSA	-0.0028^{+}	16.1593	0.0004	-0.0037*	0.0176	-0.0053	-0.0007	0.0115
	(0.0015)	(9.9013)	(0.0049)	(0.0019)	(0.0550)	(0.0069)	(0.0029)	(0.0219)
Conception Started 0-1 Years After MLSA	-0.0051*	23.3607^{+}	0.0000	-0.0035	0.0721	-0.0081	-0.0068^{+}	0.0206
	(0.0021)	(13.9400)	(0.0065)	(0.0025)	(0.0736)	(0.0096)	(0.0037)	(0.0323)
Conception Started >1 Years After MLSA	-0.0030	4.1118	0.0082	0.0001	0.0355	-0.0105	-0.0060	-0.0795^{+}
	(0.0030)	(19.1546)	(0.0095)	(0.0033)	(0.0996)	(0.0140)	(0.0051)	(0.0447)
Obs	38,659	42,388	42,388	42,388	42,403	42,403	42,403	42,283
MLSA Law Mean	0.187	0.241	0.241	0.241	0.241	0.241	0.241	0.241
Dep. Var. Mean	0.005	3228.435	0.060	0.008	38.776	0.121	0.020	8.728
Adjusted R^2	0.028	0.036	0.009	0.023	0.026	0.011	0.015	0.083
# Clusters	701	702	702	702	704	704	704	692
Policy Lead Joint p-Value	0.093	0.871	0.712	0.374	0.387	0.890	0.768	0.662

Standard errors in parentheses
Population of women giving birth <18 years of age that were conceived between 1/1/2010 and 1/1/2016 (only through 1/1/2015 for mortality). Controlling for mother's race, age, payment source, order of birth, cigarette taxes at point of gestation, cigarette and ENDS indoor air laws in bars, private workplaces, and restaurants, month-year of gestation, and county. Standard errors are clustered at the level of county.
$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1: Cigarette Question from Revised Birth Record

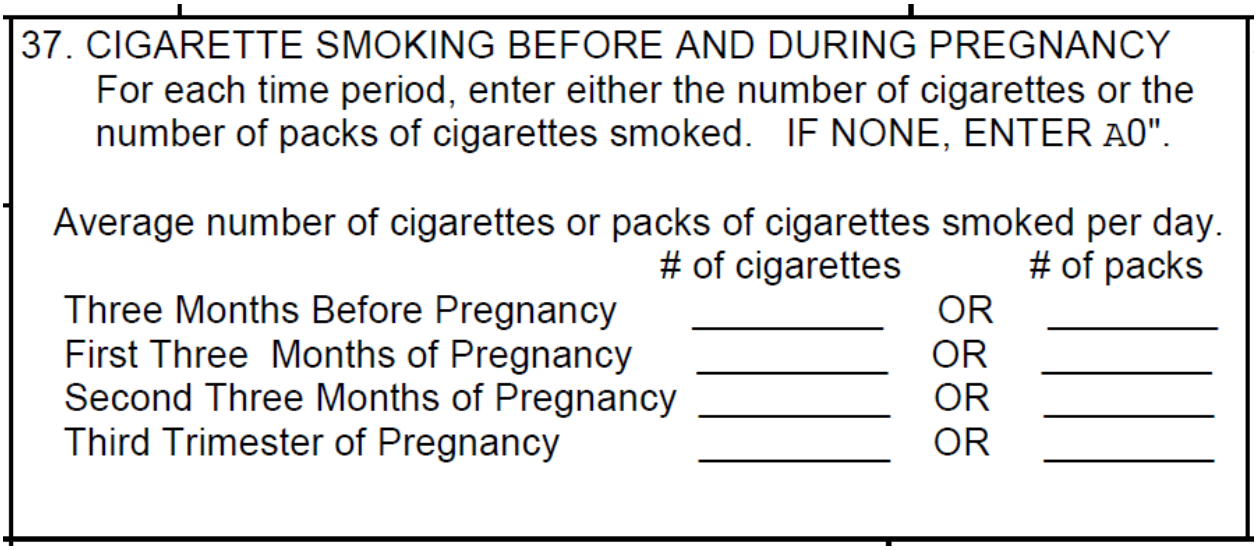
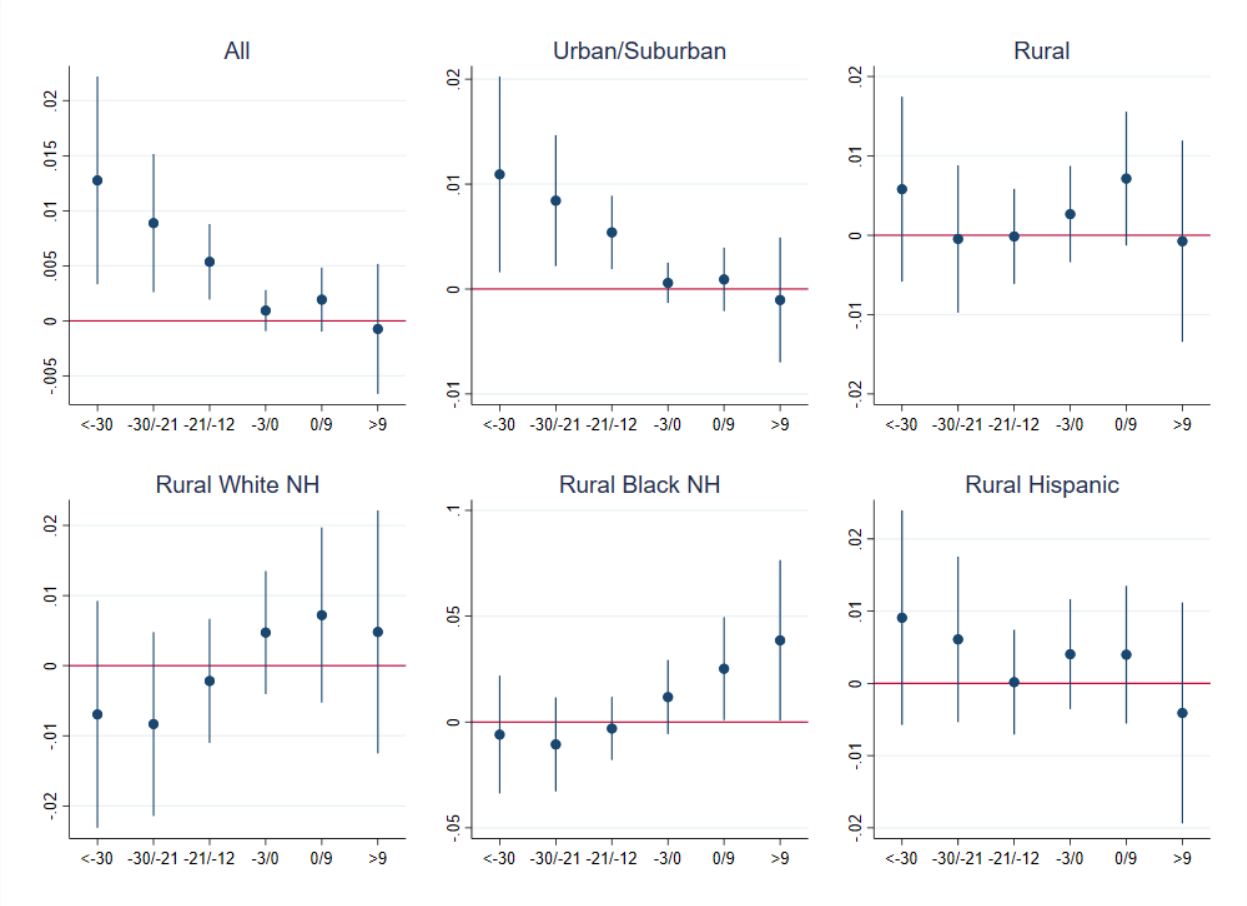
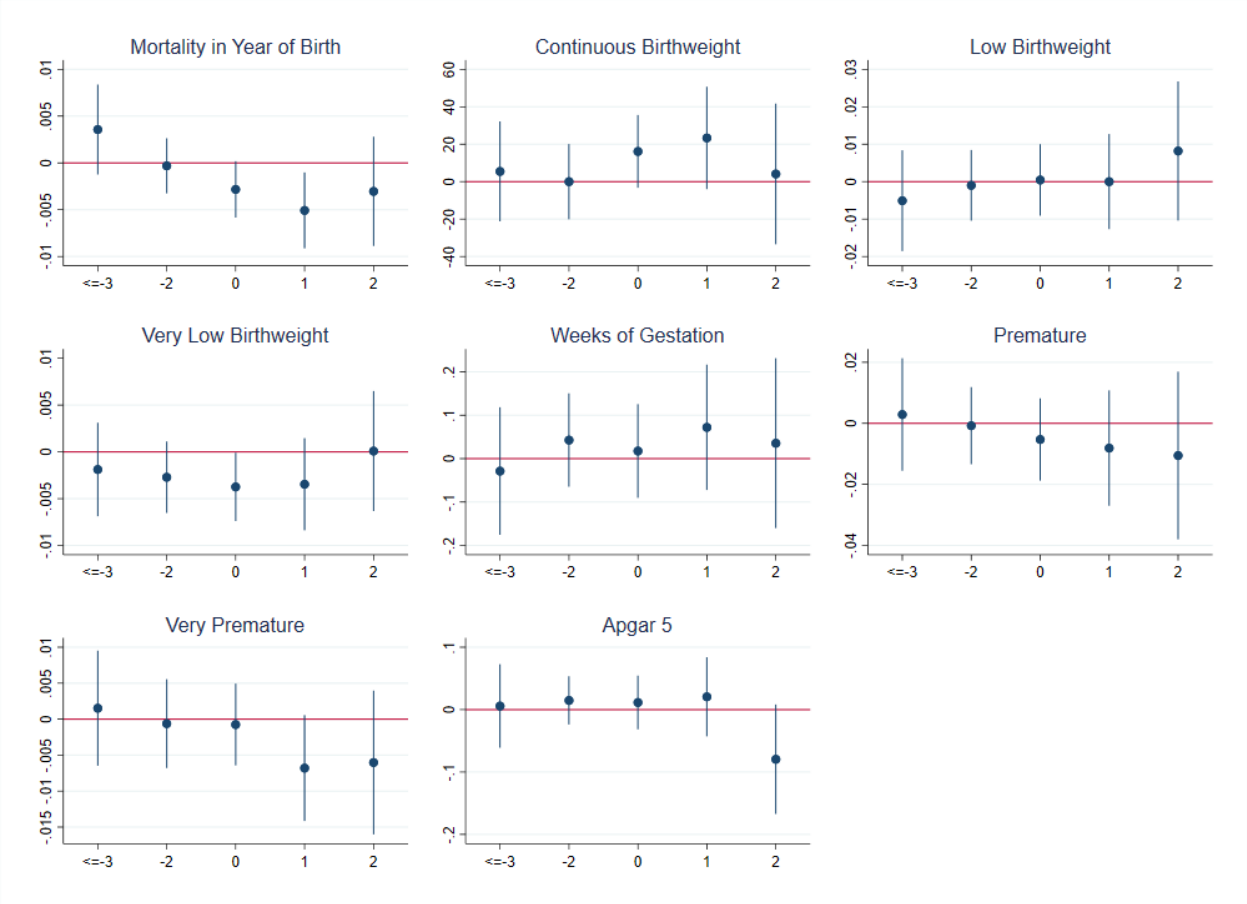


Figure 2: Effect of Any MLSA Law on Smoking Participation, Longitudinal, Event Study



Results are also presented in Table 3.

Figure 3: Effect of Any MLSA Law on Smoking Participation, Longitudinal, Event Study



Results are also presented in Table 7.

Appendix Table 1: ENDS MLSA Law Enactment Dates for States and Counties Meeting Inclusion Criteria

State	Date of ENDS MLSA Law
California	9/27/2010
Colorado	3/25/2011
Delaware	6/12/2014
District of Columbia	10/1/2015
Florida	7/1/2014
Idaho	7/1/2012
Illinois	1/1/2014
Indiana	7/1/2013
Iowa	7/1/2014
Kansas	7/1/2012
Kentucky	4/10/2014
Maryland	10/1/2012
Missouri	10/10/2014
Montana	1/1/2016
Nebraska	4/9/2014
Nevada	10/1/2015
New Hampshire	7/31/2010
New Mexico	6/19/2015
New York	1/1/2013
North Dakota	8/1/2015
Ohio	8/2/2014
Oklahoma	11/1/2014
Oregon	1/1/2016
Pennsylvania*	8/8/2016
South Carolina	6/7/2013
South Dakota	7/1/2014
Tennessee	7/1/2011
Texas	10/1/2015
Utah	5/11/2010
Vermont	7/1/2013
Washington	7/28/2013
Wyoming	3/13/2013
County	**Date of ENDS MLSA Law**
Santa Fe County, NM*	2/13/2014
Cattaraugus County, NY	2/14/2012
Multnomah County, OR*	4/4/2015
Philadelphia County, PA*	3/27/2014
King County, WA	12/16/2010
Spokane County, WA	3/31/2011
Pierce County, WA	6/2/2011
Clark County, WA	6/23/2011

Note: This table shows states used in the analysis, all of which began using the revised birth record form on or before 2010. In addition to the state-level variation, we also show counties with an ENDS MLSA in the absence of a state law. * Indicates enactment of law after 2/1/2014, which is the cutoff of conception date for our sample of births. ** Passage due to the Food and Drug Administration's 2016 Deeming Rule

Appendix Table 2: Descriptive Statistics from Birth Records for Births in Rural Counties, 2010-2016

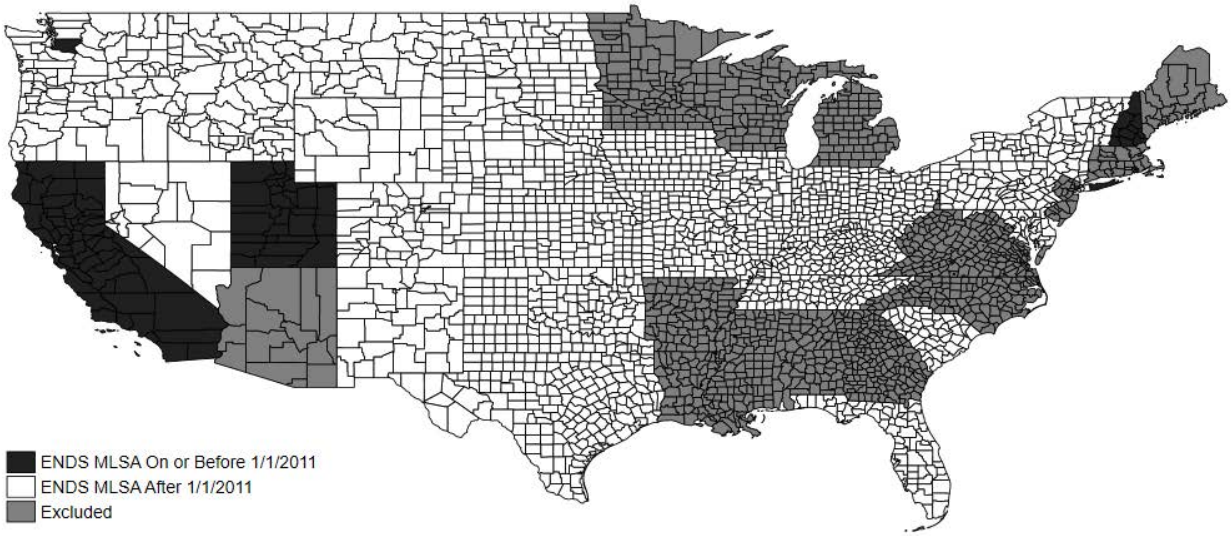
	mean	sd	mean	sd	Mean	Sd
Smoking Participation Before Pregnancy	0.183	0.387	0.159	0.366	0.174	0.379
Smoking Participation in First Trimester	0.139	0.345	0.121	0.326	0.129	0.335
Smoking Participation in Second Trimester	0.115	0.319	0.099	0.298	0.101	0.302
Smoking Participation in Third Trimester	0.108	0.311	0.094	0.292	0.096	0.295
White non-Hispanic	0.576	0.494	0.584	0.493	0.660	0.474
Black non-Hispanic	0.070	0.255	0.059	0.236	0.054	0.227
Hispanic	0.282	0.450	0.269	0.444	0.208	0.406
Other non-Hispanic or Missing	0.072	0.258	0.088	0.283	0.078	0.268
14 or younger	0.038	0.191	0.036	0.187	0.036	0.185
15	0.115	0.319	0.111	0.315	0.115	0.319
16	0.296	0.456	0.287	0.452	0.277	0.447
17	0.551	0.497	0.565	0.496	0.572	0.495
Medicaid	0.764	0.424	0.769	0.421	0.777	0.416
Private Insurance	0.151	0.358	0.154	0.361	0.150	0.357
Self-pay	0.039	0.195	0.042	0.201	0.034	0.181
Indian Health Service	0.008	0.091	0.007	0.080	0.003	0.058
CHAMPUS/TRICARE	0.003	0.053	0.002	0.047	0.004	0.060
Other government insurance	0.010	0.100	0.011	0.105	0.011	0.104
Other	0.018	0.133	0.010	0.099	0.009	0.095
Unknown	0.006	0.079	0.005	0.070	0.011	0.106
Mother's birth count (living and dead)	1.126	0.385	1.114	0.372	1.120	0.381
Birth weight (in grams)	3222.012	498.038	3241.388	491.605	3247.469	503.405
Low Birth Weight (<2500 grams)	0.061	0.240	0.056	0.231	0.057	0.231
Very Low Birth Weight (<1500 grams)	0.008	0.087	0.006	0.078	0.008	0.087
Gestation Length (in weeks)	38.763	2.614	38.778	2.521	38.842	2.586
Premature Birth (<37 weeks)	0.123	0.328	0.116	0.320	0.117	0.321
Very Premature Birth (<32 weeks)	0.019	0.138	0.021	0.144	0.018	0.134
Apgar 5 Score	8.720	0.971	8.769	0.910	8.740	0.971
ENDS MLSA	0.000	0.000	0.316	0.465	1.000	0.000
Cigarette taxes ($)	1.213	0.665	1.203	0.824	1.215	0.966
Cigarette private workplace indoor use law: None	0.385	0.486	0.298	0.458	0.150	0.357
Cigarette private workplace indoor use law: Partial	0.155	0.362	0.189	0.391	0.203	0.403
Cigarette private workplace indoor use law: Full	0.461	0.498	0.513	0.500	0.647	0.478
ENDS private workplace indoor use law: None	0.995	0.069	0.992	0.088	0.973	0.162
ENDS private workplace indoor use law: Full	0.005	0.069	0.008	0.088	0.027	0.162
Cigarette restaurant indoor use law: None	0.378	0.485	0.298	0.458	0.150	0.357
Cigarette restaurant indoor use law: Partial	0.219	0.413	0.223	0.417	0.281	0.450

Cigarette restaurant indoor use law: Full	0.403	0.491	0.478	0.500	0.569	0.495
ENDS restaurant indoor use law: None	0.995	0.069	0.992	0.088	0.973	0.162
ENDS restaurant indoor use law: Full	0.005	0.069	0.008	0.088	0.027	0.162
Cigarette bar indoor use law: None	0.574	0.494	0.529	0.499	0.464	0.499
Cigarette bar indoor use law: Partial	0.061	0.239	0.082	0.275	0.101	0.302
Cigarette bar indoor use law: Full	0.365	0.481	0.389	0.488	0.435	0.496
ENDS bar indoor use law: None	0.995	0.069	0.992	0.088	0.973	0.162
ENDS bar indoor use law: Full	0.005	0.069	0.008	0.088	0.027	0.162
Observations	28871		4459		8746	

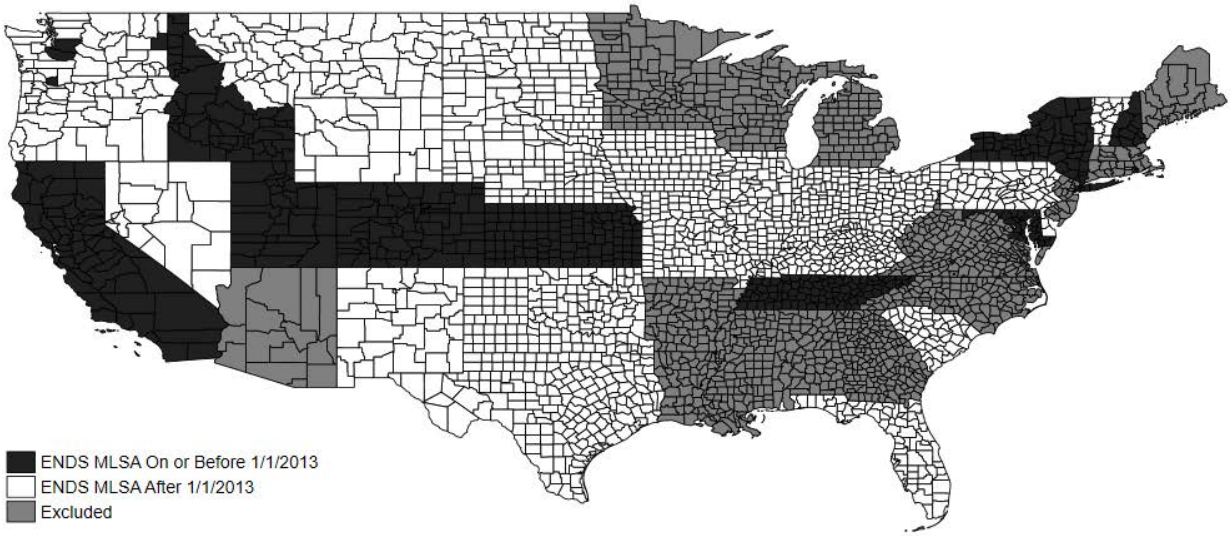
Population of women giving birth <18 years of age from rural areas of 32 states meeting inclusion criteria. Policy variables are as of the start of the first trimester.

Appendix Figure 1: Map of ENDS Policy Environment

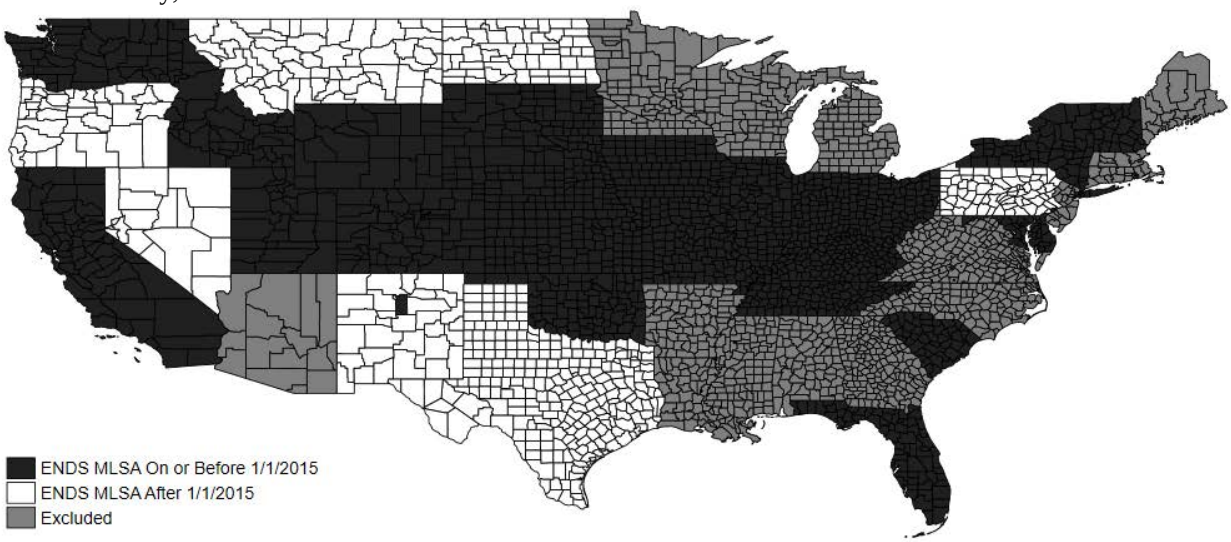
Panel A: January, 2011



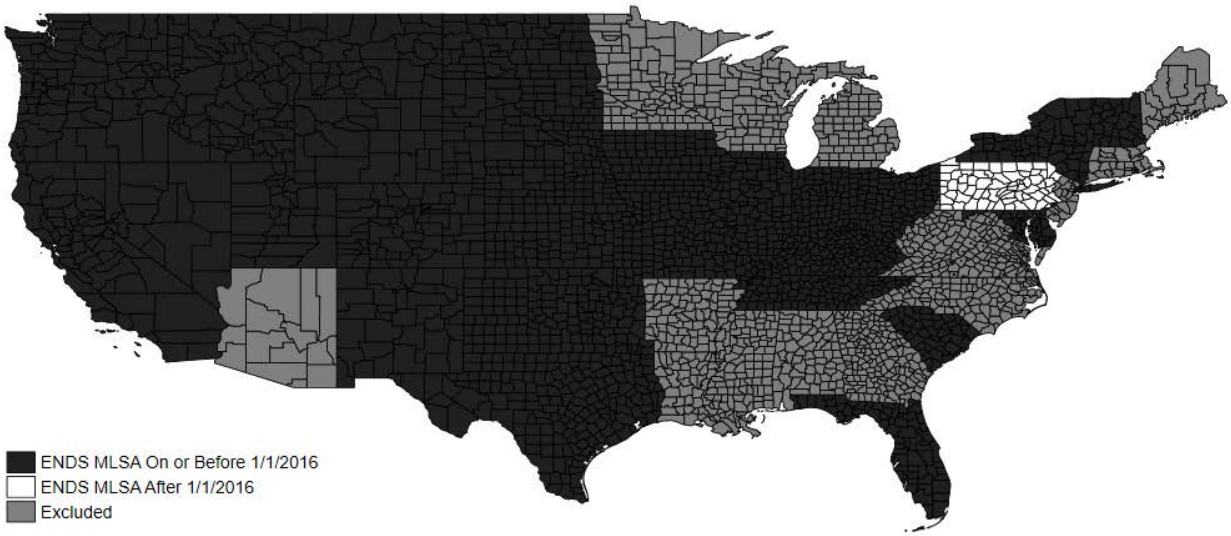
Panel B: January, 2013



Panel C: January, 2015



Panel C: January, 2016



Note: Hawaii and Alaska both used unrevised birth records. Records are excluded due to having an MLSA >18, poor data quality, and/or MLSAs primarily being passed at the city level.